

University of  
**Salford**  
MANCHESTER

## **Salford Energy House**

An overview

[www.salford.ac.uk/energy](http://www.salford.ac.uk/energy)



# The Salford Energy House testing facility

## Background

A unique testing asset, the Energy House is the only full-scale building in an environmental chamber in Europe and the only full-scale, brick-built test facility in a controlled environment in the world. The test facility (Energy House) has been designed and developed to allow leading academics and researchers to conduct scientific research, to improve the energy efficiency of “hard to treat” properties, in collaboration with industry.

This includes the development and testing of new materials, systems and products as well as looking at behaviour change associated with the adoption of energy efficiency measures in the home.

The Energy House is also breaking new ground in terms of Building Physics, carrying out many verification tests for methodologies that are currently used (and being developed) to test the energy performance of buildings and address the gap between design and as-built performance.

## Construction

The house is a traditionally constructed, terraced building (with a neighbouring property). It has solid brick walls, suspended timber floors, lath and plaster ceilings and single glazed windows. In its current state it is uninsulated. The heating is provided by a wet central heating system, fired by a gas condensing combination boiler. All of this can be changed to suit the testing requirements required by clients.

## Chamber environment

The external environment surrounding a dwelling can potentially make a significant difference to how much energy is required to heat the building. It is for this reason that we have developed the chamber to recreate a series of external weather conditions:

- Rain (up to 200mm each hour)
- Temperature ranges from -12°C to +30°C (with an accuracy of +/- 0.5°C)
- Wind (localised and chamber wide) upto 10 m/s
- Snow.

## Monitoring

The test facility uses several different monitoring equipment, all logging and displayed through a custom time series program. This provides live data feeds and real time analysis of the following data points. Currently the Energy House has over 200 sensors which are able to read down to 1 second resolution. This can generate over 2.8 Gigabytes in a week-long test.

## Past tests

Since opening, the following funded testing has taken place

- Performance of building controls (TRV and thermostats)
- Performance of insulation solutions (of all kinds)
- Testing of various building performance tests (Coheating, in situ U value monitoring etc.)
- Door and window heat loss testing
- Monitoring the performance of electrical heating systems.

**The Energy House, a traditional style terrace house, with two rooms on the ground floor (living room and kitchen diner), the upstairs consist of two bedrooms and a bathroom.**

# Monitoring and data analysis

The test facility uses a range of monitoring equipment which logs data and displays it through a custom time series program. This provides live data feeds and real time analysis of the data points listed below. Currently the Energy House has a large number of sensors which are able to read down to one second resolution.

This can generate over 2.8 Gigabytes in a week-long test. The Energy House is an exceptionally flexible test facility, which is reflected in its monitoring system that accepts a variety of sensor configurations. In this way, every test setup is unique. However, a typical setup for an experiment is given below:

Measurement	Locations	Number of sensors
Air temperatures	Every corner of each room at three different heights; centrally in each room, floor void and roof void	89
Relative humidity	Centrally in each room, floor void and roof void	7
Chamber air temperatures and relative humidities	Side, front and rear	3
Heat meters (measuring energy output)	On each radiator and complete flow and return circuit	7
External thermal imaging	Side, front and rear	3
Electricity consumption and power	Mains incoming, individual circuits and individual appliances	25
Gas consumption	Taken from main using MID meter and counter	1
Heat flux	Each external element (walls, floor and roof)	Approximately 25
Boiler performance	Flue temperature, flow and return temperature and rates and pipe temperatures.	8

All of this information is fed through a wired network to a server. From here the data is collected and analysed using a custom piece of software. This can then be accessed by researchers whether working on campus or over the internet via a web page.

Real time analysis and calculation can also be carried out, which aids the prediction of thermal constants and helps predict when steady state conditions will occur as part of an experiment.

# Academic work and partnerships

## St Gobain Research (Paris): Rapid building performance evaluation tool

The project involved an investigation and verification of a unique and patented test methodology known as the QUB method. This is designed to rapidly determine the energy performance of a dwelling. This test can be carried out in approximately 48 hours, which is currently quicker than all other similar methods. The project involved conducting a series of tests over a 6 week testing window using dynamic and steady state temperatures in the chamber. This work was published through the International Energy Agency in 2013 as a joint piece of research between the Energy House team and Saint Gobain.



Researchers

**Guillaume Pandraud** Guillaume.Pandraud@saint-gobain.com

**Richard Fitton** R.Fitton@salford.ac.uk

## Leeds Metropolitan University: Whole house heat loss testing/co-heating

Leeds Metropolitan University is regarded as a leader in field-based energy performance monitoring, having developed a methodology for whole house heat loss measurement. This is widely cited and used by many building performance evaluators. Teams from Leeds and the University of Salford are currently working on verifying the methodology and developing it further using the Energy House as a test bed. This involves testing the methodology under steady state and dynamic chamber temperatures, as well as new novel methods of testing using systems already installed in a typical house. This work is due to be published in spring 2014.



Researchers:

**David Farmer** D.A.Farmer@leedsmet.ac.uk

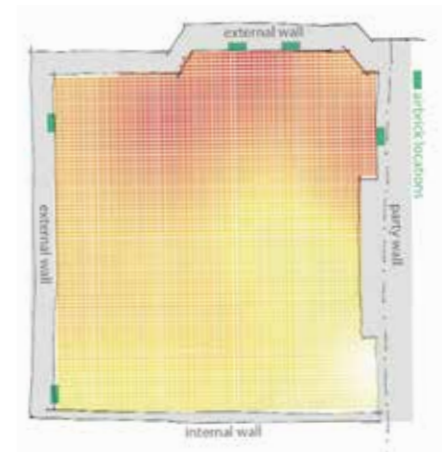
**Richard Fitton** R.Fitton@salford.ac.uk

## University College London: Development of U Value measurement for suspended timber floors

The measurement of heat loss through any floor is difficult to model and to measure. This is further complicated with a suspended floor as a varying amount of air passes through the void at any one time. In addition many junctions and both regular and irregular thermal bridges can occur (such as floor boards, joists and fixings).

A project was devised to carry out a high resolution study of heat transfer through the ground floor of the Energy House, under controlled and steady state conditions. This involved the use of over 25 heat flux transducers to measure and monitor heat loss through the ground floor. This led to what we believe to be the clearest data available worldwide for heat loss through a suspended floor under steady state, but real world, conditions.

**Figure 1** Diagrammatic heat map to visualise the variation of measured floor heat-loss, based on 14 locations in the Salford Energy House living room



**Figure 1**



Researchers:

**Sofie Pelsmakers** sofie.pelsmakers.11@ucl.ac.uk

**Richard Fitton** R.Fitton@salford.ac.uk



## Case study: Green Deal Trial Monitoring Project

The Green Deal Trial Monitoring Project, being carried out on behalf of the Department for Energy and Climate Change (DECC), is investigating the impact of sustainable retrofits on the performance of homes and outcomes for occupants. We are partnering with the Greater Manchester Low Carbon Hub, which works with 10 local authorities and social housing providers in the region.

### Objectives

The Green Deal Trial Monitoring Project breaks from the practice of using models such as RdSAP by investigating actual performance of improved homes, the impact on occupants and some of the associated risks of sustainable retrofit.

### What we are doing

- Monitoring internal conditions and rate of energy use, using a set of wireless sensors
- Conducting a series of interviews with occupants to assess comfort levels
- Measuring the rate of heat flow through the walls (U value testing)
- Using infrared images to assess the performance of the whole building and identifying patterns of heat loss
- Measuring the rates of air permeability of the building.

### Outcomes

The study is currently at the mid-way point. Initial findings are;

- Sustainable retrofit to one part of the sample triggered a 50% improvement in performance
- A post-retrofit study of occupants highlighted a considerable improvement in comfort in their newly-improved properties.



## Case study: BEAMA Heating Controls Group

The BEAMA (British Electrotechnical and Allied Manufacturers' Association) Heating Controls Study project is designed to assess the impact of different heating control sets on the consumption of energy in heating a home. The study aimed to bridge the gap between laboratory-based work and fieldwork, neither of which fully recreate a real-life, yet controlled, environment.

### Objectives

The study looked to assess the impact of three different types of control arrangements and how they affected energy consumption, internal room temperatures and system performance.

- Boiler thermostat only (no local controls)
- Boiler thermostat and living room thermostat.
- Boiler thermostat, living room thermostat and thermostatic radiator valves (TRVs).

### What we did

- Recreated average winter temperatures by holding the environmental chamber at 5°C.
- Designed and installed a heating system to CIBSE Domestic Heating Design Guide standard.
- Collected data on gas and electricity consumption, internal temperatures, flow and return rates and temperatures and mean radiant temperatures.

### Results

- Adding a thermostat to the heating system reduced the energy cost by 12%
- Adding both a thermostat and thermostatic radiator valve (TRV) reduced the energy cost by 40.7%.

Tests carried out	24 hr heating cost	Reduced cost from control
1 - No temperature control	£5.31	0%
2 - Control by room thermostat only	£4.68	12.0%
3 - Control by room thermostat + TRV's	£3.15	40.7%

"We have used the Energy House test facility for a number of tests that we don't believe could have been carried out anywhere else.

The staff are both friendly and professional and we would certainly recommend this facility to other manufacturers of energy saving technologies."

**Colin Timmins, director of BEAMA's UK controls manufacturers' association**



# Case study: Saint-Gobain – whole house retrofit

Over a period of three months, Saint-Gobain worked closely with Salford University, Leeds Metropolitan University and Saint-Gobain Recherché on what is believed to be the most in-depth study into whole house retrofit.

What attracted Saint-Gobain to the Energy House was the opportunity to work in a facility where climatic conditions could be maintained, varied and repeated and the results accurately monitored, providing the confidence that the results were due to our interventions with no extraneous factors obscuring performance.

## Objectives

The objective of this phase of testing was to carry out a full retrofit of the building, but in a way that allowed stage by stage savings to be visible, in terms of performance changes in whole house heat loss and air permeability. This was to be carried out under closely controlled and observed conditions.



External wall insulation to gable



Removal of existing floor in preparation for under floor insulation

## What we did

The approach to the project was based upon a multi-comfort and fabric-first approach, key components of Saint-Gobain's strategy. Multi-comfort is about careful teamwork, preparation, detailing and workmanship to achieve best practice, and a significantly more comfortable and healthy internal living space for occupants.

A fabric-first approach determines that performance of the building fabric should be addressed before improvements to heating and renewables are considered. However, they also wanted to understand the performance that can be achieved from a conventional whole-house retrofit – this was not about trying to achieve utopian performance levels.

Standard systems were installed and designed to achieve insulation levels required by Building Regulations. Areas that are often seen as difficult to insulate, such as loft eaves and external window reveals, were left untreated as might commonly occur in typical refurbishments, providing data to understand the dynamics of thermal performance and airtightness at these junctions in controlled conditions.

The project team, led by Simon Gibson, R&D Manager, Saint-Gobain UK spent three months at the Energy House and the close collaboration between Leeds Metropolitan University, Salford University and Saint-Gobain Recherché resulted in measurements being taken by 414 sensors to compare pre-and post-installation energy performance, air leakage and comfort.

The 'baseline' was set at a level representative of the majority of UK housing. So, instead of starting with the single-glazed windows of the Energy House, typical 1990's double-glazing was installed – reflective of windows found in many properties but which would benefit from improved glazing unit upgrades. The old loft insulation was retained and topped up to today's standards. Finally, in order to test multiple solid wall insulation measures and to reflect the 'hybrid' approach they chose to install internal wall insulation on the front elevation and external wall insulation on the side and rear elevations.



Data was logged continually for the period of the trial



Rear elevation, with external wall insulation



Floor insulation installation with vapour permeable membrane

## Results

Saint-Gobain and the project team were delighted to find that the whole-house results were as calculated and the Saint-Gobain systems installed, in combination, reduced the heating demand of the property by 63%.

Taking an average gas fuel price for Manchester in 2012, this house could be heated for less than £4 per week – a saving of almost £350 per year to the energy costs of a small dwelling. The CO<sub>2</sub> saving of 1.45 tonnes pa is equally important in contributing to climate change targets. It was also notable that a 50% reduction in air-leakage resulted from the interventions made and this, in combination with the thermal improvements, resulted in a more comfortable internal environment where more of the house could be used with no impact on energy costs, showing the value in a whole-house, holistic approach to retrofit.



## Case study: Radfan

Radfan is a new-to-market product which moves warm air efficiently around a room to increase the thermal comfort of the occupants. It comprises low power fans contained in units that sit on a domestic radiator.

### Main Objective

The company had already carried out multiple field tests of the product in the field but wanted to see if its success could be replicated in a controlled, yet real world, environment.

### What we did:

We recreated the temperature of an average winter by keeping the chamber at 5°C and collected data using a range of sensors that included the radiator surface temperature, air temperature at various points in the room, heat flux measurements, gas consumption and the electric consumption of the Radfan devices.

### Results

Test results showed that Radfan:

- Reduced thermal stratification by 2.5°C
- Reduced whole house gas consumption, saving around £30 a year from the gas bill
- Saved 1.85 tonnes of CO<sub>2</sub> over the lifetime of the device.



“When it came to proving the effectiveness of the Radfan, we were really keen to test the product in an environment that closely reflected a real life home. We wanted to avoid testing in classic scientific lab conditions as any results may be difficult to reproduce in real homes by our customers.

The Energy House was therefore the natural choice for us to make sure that the Radfan would work in the majority of UK homes.”

**Roland Glancy, Inventor of Radfan**



## Case study: Combisave

Combisave is a device fitted onto a combination boiler to save water and gas during the heating of domestic hot water.

After conducting a series of field tests, the company approached The Energy House team to carry out a flow test on the unit under controlled internal and external conditions.

### Objectives:

- Study flow rates and temperature of the hot water outlet in the kitchen
- Test a prototype device
- Film a video of how to install the unit.

### What we did:

- The environmental chamber was held at 5°C
- The Viessmann combination boiler in the Energy House was fitted with a Combisave device
- The house temperatures were set to 21°C in the main living area and 18°C in other areas
- Flow and temperature was recorded from the hot water outlets.

### Results:

Combisave used the data to ratify the design of the unit and successfully launch it into the market, achieving sales of 30,000 units in the first year of trading.

“Developing a new innovation, bringing it to market and bringing it to people’s attention is very difficult but it would have been a whole lot harder without the support of the Energy Hub team at the University of Salford.”

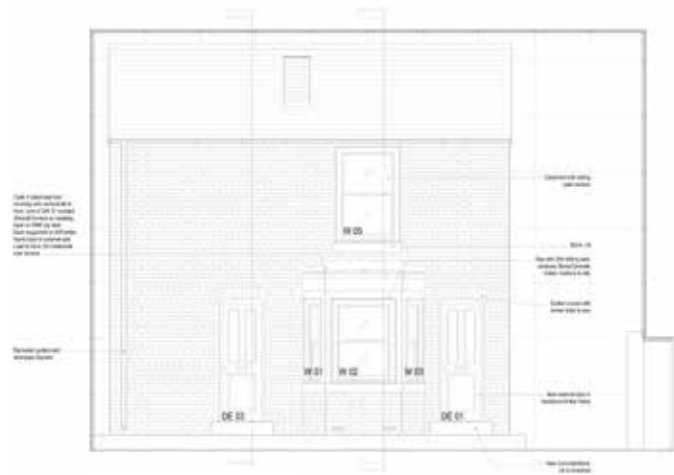
**Combisave 2014**



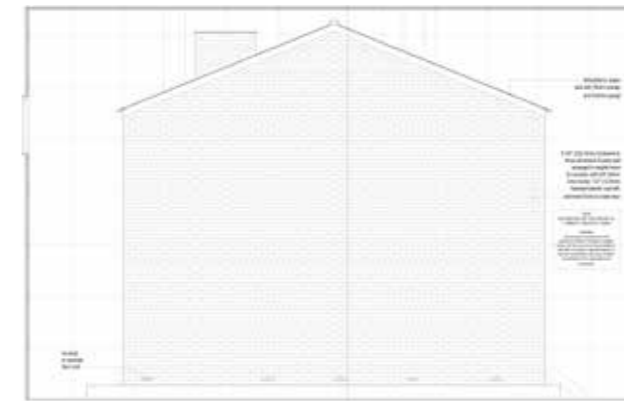
# CombiSave



# Appendix A: drawings



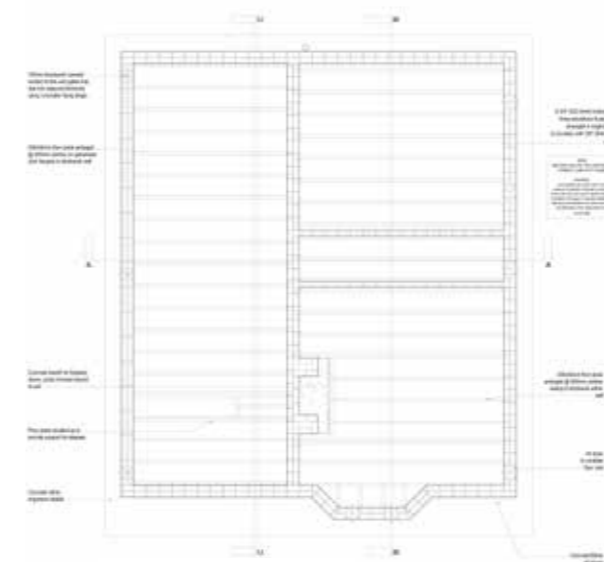
Front elevation



Side elevation



Rear elevation



Ground floor



Above: Front elevation Below: Rear Elevation

Above: Side elevation Below: Lower ground floor and kitchen





Energy House Test Facility  
College of Science & Technology  
Cockcroft Building  
University of Salford  
M5 4WT

t: +44 (0) 161 295 6804  
[www.salford.ac.uk/energy](http://www.salford.ac.uk/energy)